CLAIMS

1. A well pumping system, comprising:

a downhole rotary pump; and

a downhole reciprocating pump operatively coupled to the rotary pump for pumping well fluid to the surface of the well.

2. The system according to claim 1, wherein the rotary pump supplies fluid power to reciprocate the reciprocating pump.

3. The system according to claim 1, wherein the rotary pump is electrically driven.

4. The system according to claim 1, wherein the rotary pump is a centrifugal pump coupled to a downhole electrical motor.

5. The system according to claim 1, wherein the rotary pump has an intake that receives well fluid and a discharge, the discharge being connected to a manifold that delivers a first portion of the well fluid discharged from the rotary pump to cause the reciprocating pump to reciprocate, a second portion of the well fluid into an intake of the reciprocating pump, and a third portion back into the well.

6. The system according to claim 1, further comprising:

an electrical motor mounted below the rotary pump for driving the rotary pump; and wherein

the rotary pump has an intake that receives well fluid and a discharge, the discharge being connected to a manifold that delivers a first portion of the well fluid discharged from the rotary pump to cause the reciprocating pump to reciprocate, a second portion of the well fluid into an intake of the reciprocating pump, and a third portion back into the well below the motor for cooling the motor.

7. The system according to claim 1, wherein the reciprocating pump comprises:

a primary piston reciprocally carried in a primary cylinder;

a secondary piston connected to the drive piston for movement therewith within a secondary cylinder, the secondary cylinder being in communication with well fluid for pumping to the surface; and wherein

a sequencing valve is operatively connected between a discharge of the rotary pump and the primary cylinder for alternative directing well fluid from the rotary pump to the lower and to the upper sides of the primary piston to stroke the secondary piston for pumping well fluid to the surface.

8.The system according to claim 1, wherein the reciprocating pump comprises:

a primary piston reciprocally carried in a primary cylinder;

a secondary piston connected to the drive piston for movement therewith within a secondary cylinder;

an intake and discharge valve mechanism that admits well fluid to the secondary cylinder while the secondary piston is moving in one direction and allows the well fluid to be pumped from the secondary cylinder while the secondary piston is moving in the other direction; and wherein the system further comprises:

a sequencing valve;

a conduit that connects a portion of the discharge of the rotary pump with the sequencing valve for alternative directing well fluid from the rotary pump to the lower and to the upper sides of the primary piston to stroke the secondary piston; and

a conduit that connects another portion of the discharge of the rotary pump to the intake and discharge valve mechanism of the secondary cylinder for pumping well fluid to the surface.

9. A well pumping system, comprising:

a downhole rotary pump having an intake for receiving well fluid and a discharge;

a downhole electrical motor connected to the rotary pump for driving the rotary pump;

a downhole reciprocating pump, having a primary piston that strokes within a primary cylinder, and a secondary piston of lesser diameter than the primary piston, the secondary piston being carried within a secondary cylinder and movable in unison with the primary piston, the secondary cylinder being in communication with well fluid for pumping the well fluid to the surface of the well; and

a sequencing valve connected between the discharge of the rotary pump and the primary cylinder for alternately supplying at least a portion of the well fluid discharged by the rotary pump to opposite sides of the primary piston for stroking the primary and secondary pistons.

10. The system according to claim 9, wherein the secondary cylinder is in communication with a portion of the well fluid discharged by the rotary pump.

11. The system according to claim 9, further comprising:

an exhaust conduit operatively connected to the sequencing valve for exhausting the well fluid from the primary cylinder as the primary piston strokes, the exhaust conduit leading downward to a point below the motor.

12. The system according to claim 9, further comprising:

an intake chamber coaxially aligned with the secondary cylinder, the intake chamber being in fluid communication with a portion of the discharge of the rotary pump;

a plunger joining the primary piston on a side opposite the secondary piston and extending into the intake chamber;

a standing valve that admits well fluid from the discharge of the rotary pump into the intake chamber during an upward stroke of the plunger and blocks flow into the intake chamber during a downward stroke of the plunger;

a passage extending through the plunger, the primary piston, and the secondary piston for delivering well fluid from the intake chamber to the secondary cylinder; and

a traveling valve in the passage for blocking the passage while the plunger moves upward and opening the passage while the plunger moves downward.

13. A well pumping system, comprising:

a string of tubing for extending into a well;

a centrifugal pump carried by the tubing and having an intake for receiving well fluid;

an electrical motor operatively connected to the centrifugal pump for driving the centrifugal pump;

a primary piston carried within a primary cylinder;

a secondary piston of lesser diameter than the primary piston, the secondary piston being carried within a secondary cylinder and movable in unison with the primary piston, the secondary piston being in fluid communication with a portion of the well fluid being discharged by the centrifugal pump;

a shuttle valve that strokes between power and exhaust positions, the shuttle valve being connected to the discharge of the rotary pump and to the primary cylinder for alternately supplying at least a portion of the well fluid discharged by the centrifugal pump to opposite sides of the primary piston for stroking the primary and secondary pistons; and

an intake and discharge valve mechanism that admits well fluid to the secondary cylinder from the discharge of the centrifugal pump while the secondary piston is moving downward direction and allows the well fluid to be pumped from the secondary cylinder while the secondary piston is moving upward.

14. The system according to claim 13, further comprising:

an exhaust conduit operatively connected to the sequencing valve for exhausting the well fluid from the primary cylinder on an exhaust side of the primary piston, the exhaust conduit leading downward to a point below the motor.

15. The system according to claim 13, wherein the intake and discharge valve mechanism comprises:

an intake chamber coaxially aligned with the secondary cylinder, the intake chamber being in fluid communication with a portion of the discharge of the rotary pump;

a plunger joining the primary piston on a side opposite the secondary piston and extending sealingly into the intake chamber;

a standing valve that admits well fluid from the discharge of the rotary pump into the intake chamber during an upward stroke of the plunger and blocks flow into the intake chamber during a downward stroke of the plunger;

a passage extending through the plunger, the primary piston, and the secondary piston for delivering well fluid from the intake chamber to the secondary cylinder; and

a traveling valve in the passage for blocking the passage while the plunger moves upward and opening the passage while the plunger moves downward.

16. A method for pumping a well, comprising:

(a) installing a rotary pump and a reciprocating pump within a well such that each of the pumps has an intake in fluid communication with well fluid in the well;

(b) rotating the rotary pump to pump well fluid; and

(c) supplying at least a portion of well fluid pumped by the rotary pump to the reciprocating pump, driving the reciprocating pump in response to well fluid being supplied from the rotary pump, and pumping well fluid to the surface of the well with the reciprocating pump.

17. The method according to claim 16, wherein step (c) further comprises supplying a portion of well fluid being pumped by the reciprocating pump to the intake of the reciprocating pump.

18.The method according to claim 16, wherein:

step (a) comprises coupling an electrical motor to the rotary pump;

step (b) comprises supplying electrical power to the motor; and the method further comprises:

directing an exhaust portion of the well fluid being pumped by the rotary pump downward to a point below the motor, and flowing the exhaust portion upward past the motor into the intake of the rotary pump.